

# L I G H T   R E F L E C T I O N   V A L U E

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ken Company, the decrease in spoilage having been notable. In such work it has been found advantageous to replace the usual black or drab paint on certain portions of the machines with white or a light tint. The increase in local illumination is found to facilitate adjustment and repairs as well as routine operation.

## IMPROVED LIGHTING OF MACHINERY

Painting certain portions of a machine around the operating level will also eliminate unequal illumination. And it has been found that, "A situation which requires the eyes to shift between bright and dark areas is unfavorable for quick and clear seeing."<sup>6</sup> In the following table are tabulated the results of about 400,000 observations made at Nela Park, Cleveland, Ohio. The foot candles will indicate the relative light and shade. In each case, the rate of work was greatest at the highest, even illumination, so the *rate of work* was taken as 100% under those conditions. This does not mean, however, equal *volumes of work* in the third and first instances.

Lighting Condition	FOOT-CANDLES		Relative Rate of Work
	Left Area	Right Area	
Uniform Illumination. . . .	20	20	100.0
Unequal Illumination. . . .	20	5	96.8
Uniform Illumination. . . .	5	5	99.0
Uniform Illumination. . . .	20	20	100.0
Unequal Illumination. . . .	20	1	89.9
Uniform Illumination. . . .	1	1	92.3
Uniform Illumination. . . .	5	5	100.0
Unequal Illumination. . . .	5	1	92.7
Uniform Illumination. . . .	1	1	91.1

<sup>6</sup> Lighting Research Laboratory, National Lamp Works of General Electric Company.

## O F C O L O R I N P A I N T

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LIGHT AIDS SHARP EYES—WHITE  
PAINT INSURES LIGHT WORKING  
PLANES

In the first and second sets of data we find a greater rate of work being done under conditions of less light, uniformly distributed, than under conditions of higher average light value unevenly distributed. These tests show how entirely misleading "average value" is in the case of illumination. The first set of data in the above table represents good working conditions which depend, however, on well reflected and diffused lighting. A white or light tint paint on the darker more obscure portions of machinery and on back walls does much to achieve these results.

ADVANTAGE  
OF UNIFORM  
LIGHTING

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# THE LIGHT VALUE OF REFLECTION COLOR IN PAINT





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THE  
LIGHT REFLECTION VALUE  
OF COLOR IN PAINT



THE  
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160 FRONT STREET      NEW YORK



THE  
BACKGROUND  
OF INDUSTRY  
—WHITE PAINT



PAINT THE MACHINERY WHITE, TOO.  
REFLECTION ADDS TO EFFICIENCY  
AND SAFETY OF OPERATION

## THE LIGHT REFLECTION VALUE OF COLOR IN PAINT

### PART I

THE interior finishing of every type of building is justly receiving more and more careful consideration. Homes, hotels and hospitals are cheerier places because of a growing knowledge of the psychology of color and an increased appreciation of the value of the light reflection property of colors. School rooms and offices are better places in which to do more and better work for the same reason. Machine shops, foundries, steel mills and coal breakers are carefully painted white or a very light tint as well as the homes of those industries more commonly considered "sanitary industries"—manufacturers of food products, laundries and manufacturers of surgical supplies. All of these at a real economic advantage.

In homes, hotels and certain public buildings the aesthetic effects outweigh other considerations; while in schools and workrooms, generally, illumination and the psychological effect of colors are the more important considerations. In industrial cases, probably the most important considerations in every case are illumination and sanitation, though here as in other cases the psychology of color is a factor to be carefully considered. In special cases, however, such as surgical operating rooms, steel foundries and the other rooms where sharp distinction of color is vital, careful selection of contrasting or of complementary colors is the most urgent.

Obviously, a white surface reflects more light than any colored surface and black, the least. In many cases, however, it is desirable to sacrifice some light reflecting value for aesthetic or psychological reasons. But this reflecting property of color should always be kept in mind and as bright a tint as possible selected. Illumination cannot be completely effective with only the primary sources, the sun and artificial lights. Diffusion and reflection create secondary sources of illumination—in the case of interiors these sources are walls, ceilings and lighting fixtures.

In the case of modern artificial lighting by far the greatest amount of light falls on the ceiling and upper portions of the walls. Mr. Luckiesh<sup>1</sup> has lighted a drafting room with a light of fifteen foot-candles throughout the working plane at a cost of thirty cents an

THE COST OF  
LIGHT

<sup>1</sup> "Lighting Value of Paint in Industrial Plants," by Mr. Luckiesh and E. W. Commerly, Industrial Engineer, August, 1926.

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## LIGHT REFLECTION VALUE

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### DEPRECIATION OF REFLECTION VALUE

hour. The ceiling of this room had a reflection factor of 80% (an ordinary white). But if that reflection factor be reduced to 50% (gray), that lighting system would run a monetary loss, within nine months, equivalent to the cost of repainting the ceiling.

In this connection, it is also important to insure the light reflection value of the interior surfaces for an economical period of time. One authority on illumination and the effect of colors on lighting may be quoted:<sup>2</sup>

"It is true that it is appreciably more expensive to paint an interior correctly than to apply calcimine or some other paint which depreciates rapidly or has initially lower reflecting power, but careful analysis reveals that the expenditure is well warranted."

In proving this point figures, based on facts accumulated through many years of research and study of the subject, are put forward:

"As a practical case one might consider a room where the ceiling is painted with a poor type of oil paint which depreciates quickly, or a water paint which usually loses its reflecting power very rapidly; lighted by semi-indirect luminaires. It is safe to assume that at the end of two years the illumination will have decreased not less than 20 per cent, due to the reduction in reflecting power of the ceiling, other conditions being constant. But actually, other conditions are not constant. The reflection power of the walls will also undergo a loss, and it is probably safe to assume that the use of poor paint alone results in a progressive loss of light amounting to at least 15 per cent of that measured at the beginning of the year. Thus a room so painted of 400 sq. ft. floor area initially lighted by four 150-watt lamps, would require an additional 150-watt lamp at the end of two years to bring the illumination back to what it was at the beginning—an increase of 25 per cent in energy consumed and lamp costs. Surely this figure is striking enough to warrant the initial expenditure for proper painting."

The illuminating Engineering Society prepared a lecture which gives another more striking example.<sup>3</sup>

<sup>2</sup> "Effect of Maintenance and Color of Surroundings on Resultant Illumination," by Mr. A. L. Powell and Mr. E. W. Prideaux, Engineering Department, Edison Lamp Works of General Electric Company.

<sup>3</sup> The Journal of the American Institute of Architects, May, 1919.

## O F C O L O R I N P A I N T

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WITH MODERN ILLUMINATION, BY  
FAR THE GREATEST LIGHT IS RE-  
FLECTED FROM CEILINGS

"In one very large office building, the suggested change from light buff-tinted ceilings to the kind of treatment suggested (cream-colored walls and white ceilings) would have saved in energy consumption for lighting about \$14,000 a year. Under these circumstances it would obviously pay to use a paint that can be thoroughly cleaned without injury and to pay the cost of cleaning at least once every six months."

Where colors are desired, tints can be selected which have comparatively good light reflection properties. In selection of these tints, though, careful guidance should be sought from fairly positive psychological findings.

It has long been known that black and gray are conducive to melancholia and general depression in sensitive persons.

EMOTIONAL  
EFFECT OF  
COLORS

## LIGHT REFLECTION VALUE

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LIGHT IS GREATLY INCREASED BY SECONDARY SOURCES IN COMPARATIVELY LOW-CEILINGED, MULTI-STORIED BUILDINGS

Red has been found to induce temporary stimulation, followed by a nervous reaction, often accompanied by headache.

Blue induces calm contentment. Yet in one instance it was found an office had to be kept several degrees warmer for the physical comfort of its occupants when the walls were changed from a buff to blue.

Green and yellow, in many persons, increase vitality and amiability. A very large manufacturer of food products whose work rooms are finished in white has found green to be an efficient "relaxing agent" in the rest rooms and company cafeteria.

# OF COLOR IN PAINT



## PART 2

IN THE consideration of colors, it is unfortunate that we lack any generally understood, definite scientific, nomenclature. The terms generally used to designate color are too broad to be of any very definite value. And it has been estimated that the human eye can distinguish about 90,000 different colors;<sup>4</sup> for besides the hues (the colors, red, blue, purple, etc.), there are tints and shades of the hues.

### COLOR NOMENCLATURE

The shades are the degrees of purity of the hues. We might speak of a strong blue or a weak blue, these are shades of the hue, blue.

The tints are the light values of the hues and shades. By "light values" the nearness to which the hue approaches white is meant. A strong red will range from a tint which is almost white to one, a dark blood red, hardly distinguishable from black.

As previously noted black has the lowest light reflective efficiency, white, the highest. And *until one reaches the very light tints*, the blues, grays, reds, purples, yellows, etc., have low light reflection factors. The darker tints are not good interior finish colors, when you are considering illumination, for they absorb more light than they reflect.

The eye can easily pick ten equal steps (tints) between white and black as has been done in the color chart on pages 10 and 11. Like divisions can be made of any hue or shade and the light reflection values compared. These divisions of brightness are purely a function of the eye. They were, in fact, first selected by Mr. A. H. Munsell,<sup>5</sup> whose work in color has done more to clarify its use and discussion than any other's.

These ten equal steps in brightness are not, however, ten equal steps in light reflectivity, nor do the value numbers designate reflection efficiency. Rather, the reflection factors are roughly in the range of the square of the value number. From this you will see that the reflection factor increases much more rapidly as the tints

<sup>4</sup> "Tints and Shades, What do they Mean?" by M. Luckiesh, Director, Lighting Research Laboratory, National Lamp Works of the General Electric Company.

<sup>5</sup> The Color Atlas by A. H. Munsell copyright, 1907, 1915, 1929.



# Color Chart Illustrating the Acceleration\* of Reflection

VALUE	LIGHT REFLECTION FACTOR	WHITE	RED
9.5	84 % approx.		
9	72.8 %		
8	53.6 %		
7	38.9%		
6	27.3 %		
5	18.0%		
4	11.05%		
3	5.95%		
2	2.9 %		
1	1.12%		

\* Note the increase in reflection value between 2 and 3 is 3.05%, but between 8 and 9

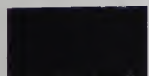
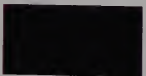
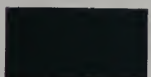
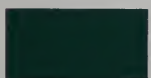
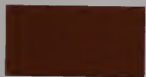
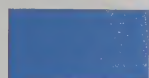
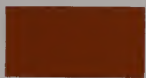
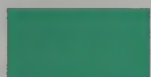
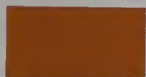
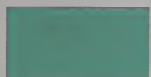
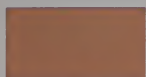
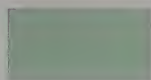
† The original colors, values and efficiencies for this chart were furnished

# Section Value as Tints Become Lighter in Color †

YELLOW

GREEN

BLUE



8 and 9 it is 19.2%—hence, "Acceleration" (see paragraph 1, page 12).  
urnished by Munsell Color Co. Inc., Baltimore, Md.



## LIGHT REFLECTION VALUE

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WHITE PAINT IN A BAKERY INSURES  
THE NECESSARY CLEANLINESS AS  
WELL AS EFFICIENT ILLUMINATION

### REFLECTION VALUE OF LIGHT TINTS

become brighter or of higher "Value." Thus the increase in light reflection efficiency between 8 and 9 (light gray and ordinary white) is over 30% greater than the increase between 7 and 8 (moderate and light gray). In other words, as the white begins to dominate the gray, the light reflection factor is increasingly improved—there is a definite acceleration of efficiency, a greater saving of money.

This accelerated increase in light reflection efficiency is equally effective in the case of the lighter tints of colors, and careful observation of the accompanying chart will clearly show the light reflection advantage of the lighter tints.

# O F C O L O R I N P A I N T



## PART 3

THE food producing industry as a whole was, for obvious reasons, probably the first to standardize on high grade white paint for interior finishing. Their incentive was, of course, sanitation; but they soon discovered additional value in increased production, due to improved morale in their employees; and decrease of accidents due to efficient illumination. A by-product—unanticipated, perhaps, but of high value—was the connotation of whiteness with purity and cleanliness in the minds of consumers. Once recognized, the advertising value of this feature has not been overlooked, and the public has now been educated to associate an immaculately white interior with clean, wholesome products.

Other industries also have discovered the economic value of white, or very light tinted paints, for interior finishing. Through experience they have come to realize, in a general way, facts which technical men have learned and established by scientific research—that adequate diffused illumination is essential to the health and contentment of workers; that the physical hazards of occupation are materially decreased thereby; and that the promotion of physical and mental well-being noticeably increases production.

In these days of enlightened practice, when industry is increasingly solicitous for the welfare of its employees, these considerations are engaging the interest of employers in general, not only because of regulative legislation, such as sanitary codes, liability laws and the like, but also because of a better understanding of the relation of health, contentment and morale to output. It has been statistically demonstrated that humane practices pay not only moral but financial dividends.

A test run in the Timken Roller Bearing Company plant at Columbus, Ohio, was reported in the August, 1925, issue of Industrial Engineering. This test was conducted in the inspection department. When the illumination was improved from five foot-candles at the working plane to twenty foot-candles, the production was increased 12.5 per cent.

In the machine shops of various plants this increase of production has been found to be even greater than that reported by the Tim-

### ADVANTAGES OF WHITE INTERIORS

## LIGHT REFLECTION VALUE

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WHITE PAINT, EASILY CLEANED, INSURES BOTH SANITATION AND EFFICIENT WORKMANSHIP IN THE MANUFACTURE OF SURGICAL SUPPLIES

### DAYLIGHT REFLECTION IN COURTS

Another situation in which reflectivity plays an important part is in the lighting of rooms opening onto courts. White paint on these court walls results in a quite unbelievable increase in interior illumination. It has been proved that "daylight illumination in the interior of a room at the bottom of a closed court can be increased *twenty times* by painting the dark colored court wall with a white or light tint paint."<sup>7</sup>

<sup>7</sup> "The Utilization of Exterior Reflecting Surfaces in Daylighting" by C. R. Randall and A. H. Martin, Transactions of the Illuminating Engineering Society, March, 1929."

## O F C O L O R I N P A I N T

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The illumination of surgical operating rooms has long been the subject of research and experiment. The old operating room was a ghastly white place; but as the "subject" entered and left it in a state of unconsciousness, he was not concerned. The surgeons, however, eventually discovered that this diffused illumination interfered with their work. Dr. Harry M. Sherman, of the San Francisco Polyclinic Hospital, after experimenting first with dark paint, finally adopted the green which is complementary to the red of blood (the green of spinach). This color was used for the floors

SPECIAL  
LIGHTING  
PROBLEMS

CLEANLINESS AND LIGHT WORKING  
SPACES ARE ESSENTIAL IN THE MAN-  
UFACTURE OF PHARMACEUTICAL  
SUPPLIES—WHITE PAINT



## L I G H T   R E F L E C T I O N   V A L U E



and the walls to a height of about six feet, and above that white walls and ceilings.<sup>8</sup>

In other departments of a hospital the selection of the finish color is almost equally important, since it is a well-known fact that convalescence can be speeded or retarded by the environment.

### DIFFERENT FORMULAS FOR VARYING CONDITIONS

These examples of paint planning will show the problem in the light of its true importance. Varying conditions make almost every case a special problem in some ways, yet past experience has formed a sound basis upon which to work.

No single paint can be called an answer to all problems. For satisfaction a paint must be used under conditions for which it was formulated. And paint manufacturers have spent large sums of money and much time building up their formulas. They will be glad to pass their information on to help you in planning your paint work.

<sup>8</sup> Technical Circular No. 34, Educational Bureau, American Paint & Varnish Manufacturers' Association, Inc., "Painting the Hospital," by G. B. Heckel, in *Hospital Progress*, 1921.





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